Equipment Design of N3 Carrier Terminals and Carrier Supply

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This paper discusses the equipment aspects of the 24-channel N3 carrier terminals and associated common carrier supply. Arrangements of the carrier equipment, in shop-wired and tested packages with associated equipment, are described. The common carrier supply equipment is reviewed. Particular attention was given to those equipment features which have to do with reliability, economy, and installation and operating convenience.

A variety of package arrangements are described and the numerous advantages resulting from the "shop-wired package" concept are explored. The equipment features of the plug-in units which are components of both carrier terminal and carrier supply are examined.

I. INTRODUCTION

The N3 carrier terminal is a 24-channel, single-sideband, transistorized short-haul carrier terminal designed for use with carrier lines using N1, N1A, or N2 repeaters. It may be connected to pairs in the same cables with N1, N2, ON1, and ON2 systems. It is the successor to the ON2 carrier terminal and is designed to meet the latest performance requirements for two-way direct distance dialing or voice band data channels. The new N3 terminals provide important transmission improvements, as compared to ON2 terminals, which are discussed in companion papers.[1,2] For reasons of economy and improved performance, these new terminals are arranged in shop-wired packages together with functionally related signaling, trunk processing, carrier supply, and channel patching jack equipment.

This paper will discuss equipment design features of both the carrier terminal and the associated common carrier supply as they affect transmission performance, economy of manufacture, engineering, installation, maintenance, operating convenience, and system reliability.

II. GENERAL DESCRIPTION

Each 24-channel terminal includes two 12-channel groups rather than the six 4-channel groups employed in the ON2 terminal. This reduces the cost per channel through a reduction in the amount and cost of common group equipment. Additional advantages in having two 12-channel groups will be discussed in greater detail in companion papers appearing elsewhere in this issue.[1,2]

The terminals are arranged to include independent 12-channel group alarm and restoral units and associated trunk release and make busy units. This equipment functions to provide an alarm in the event of system failure, to properly process the associated trunks when failure occurs, and to restore the trunks to service automatically upon system restoral.

The N3 terminals obtain the various group, channel group, and channel carrier frequencies from a common carrier supply which is designed to provide the necessary frequencies for up to twenty-six N3 terminals. The carrier supply is discussed in greater detail in another section of this paper and in two companion papers.[1,2]

The terminals are designed for operation with E-type in-band signaling for transmission of dial pulses and supervisory signals over the N3 channels. The E signaling equipment is included in the same shop-wired package with the terminal equipment. No provision is made in an N3 terminal for built-in out-of-band signaling such as was used in ON2 and N1 systems. All of the currently available E-type signaling units may be used with N3 carrier channels.

Even though N3 is a superior transmission system with more features and better performance, the price per installed carrier channel will generally be less than that for ON2 carrier channels except for small installations. A substantial price advantage is realized from the shop-wired "packaged terminal" arrangement, from the reduced power requirements of transistorized circuitry, and from reduced space and central office cabling requirements. A more detailed description of the various equipment features follows.

III. CARRIER TERMINAL EQUIPMENT

Except for resistance networks for combining signals and certain equipment which is common to a "terminal package", the equipment for one carrier terminal consists of seventy-one plug-in units. Printed wiring board extensions on the units interconnect to associated equipment when inserted into in-line connectors on the terminal mountings.

Shop-wired strapping and local cable then provide the connections between unit connectors and to the channel patching jacks, E signaling equipment, trunk release and make-busy equipment and fuses in the same package bay. Three important advantages accrue from the plug-in unit arrangement: (*i*) inoperative or malfunctioning units may be easily replaced by spares for prompt service restoral; (*ii*) relatively inexpensive bay equipment may be engineered and installed for future growth and the cost of the more expensive units deferred until later; (*iii*) units needing repair or readjustment may be shipped to repair centers where the work can be done by well-equipped and highly-skilled specialists.

The plug-in units for an N3 terminal are contained in six die-cast aluminum shelves with one shelf cover casting above the top row of units. Each shelf is provided with cast guides for 12 module positions. The shelves are located one above the other and so designed that associated plug-in units are held in place laterally by cast guides on the top of one shelf and the bottom of the shelf above. The shelf cover casting includes the upper guides for the units on the top shelf. The arrangement of units is shown pictorially in Fig. 1 and the shelf and cover castings are shown in Fig. 2.

The plug-in compandor and channel modem units for the 12 channels in channel group 1 are located on the lower two shelves of a terminal. Units for channel group 2 are similarly located on the two upper shelves. The two middle shelves provide space for a plug-in 48-volt to 21-volt dc-dc converter power supply unit, 12 double-channel regulators, two channel group modems, two alarm and restoral units, two frequency correcting units, a group receiver unit, a group transmitter unit, a combining and switching unit, and a line terminating unit. Resistance combining networks for each of the two 12-channel groups are arranged on printed wiring boards attached to a mounting plate. This plate is mounted on the rear flange of the bay between the shelves. Designation card holders are located on the bay upright at the left end of each shelf and are equipped with standard cards having spaces for essential operating company information.

IV. PACKAGED BAY EQUIPMENT — GENERAL

The equipment arrangements for the N3 carrier terminal have been designed to locate the carrier terminal with other closely associated equipment in a shop-wired package. In addition to the carrier terminal, the shop-wired package includes signaling equipment, voice-fre-

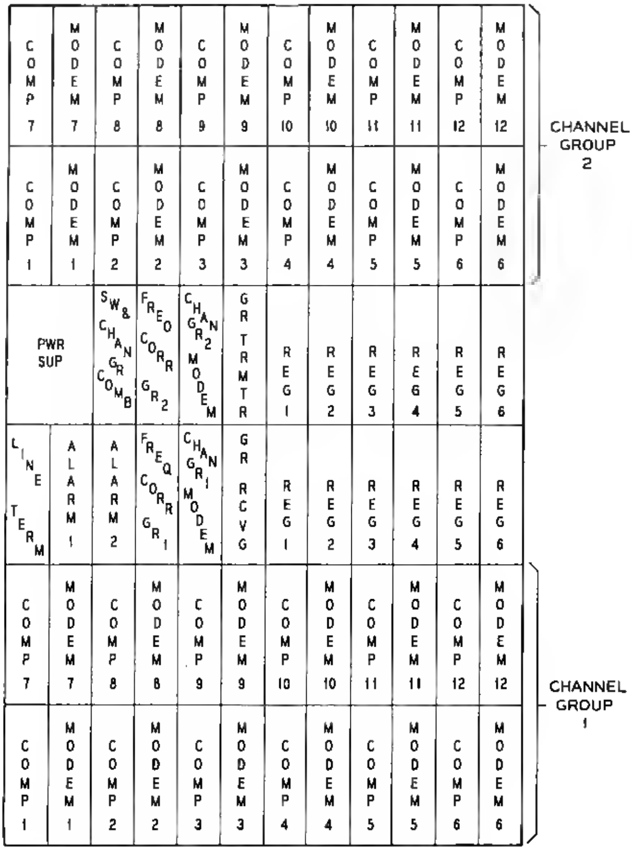


Fig. 1 — N3 carrier terminal — location of plug-in units.

quency patching jacks, and jacks and switches for access to and control of voice-frequency transmission and noise measuring equipment; trunk release and make-busy equipment; battery filtering and distribution equipment; common bay alarm equipment; and miscellaneous common equipment.

Heretofore, the associated major equipment items would have been located in separate bays and interconnected through the distributing frame by cabling run and connected in the central office by the installer. The reduction in central office cabling and connections achieved by this new design concept is clearly demonstrated in Fig. 3. Not only is a substantial amount of installation and engineering work eliminated, but the interconnections made during manufacture are less ex-

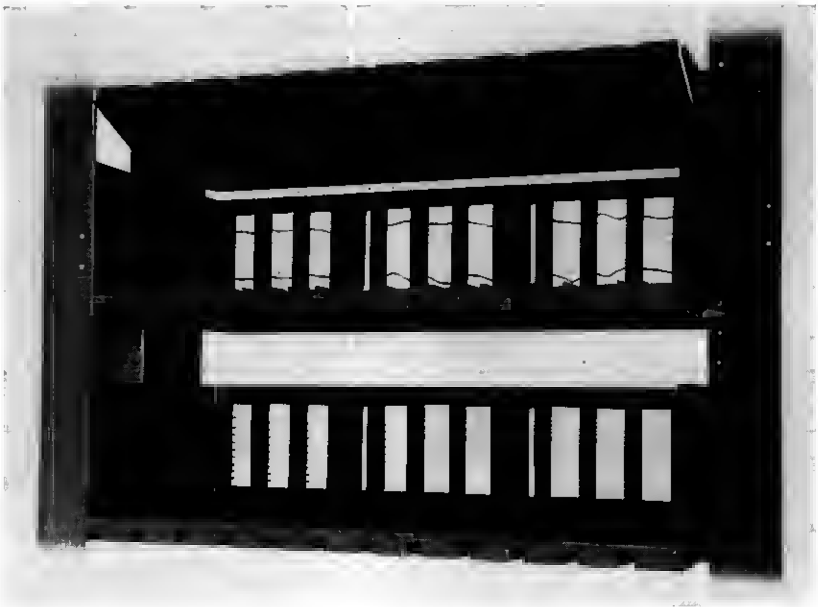


Fig. 2 — Die-cast shelves.

pensive and are completely and efficiently tested by sbop testing consoles. The exposure to central office noise and crosstalk pickup is reduced, and the problems of cable rack congestion and segregation of voice and signaling cabling from carrier line cabling are substantially lessened. Existing office arrangements were designed to meet strict resistance limits on some of the E-type signaling leads prior to the development and addition of trunk release and make-busy equipment. Including this new equipment in the signaling path would often require office recabling to stay within resistance limits if the various associated equipments were on separately located bays.

In servicing and maintaining the terminal equipment, there is some advantage in having associated equipment conveniently located together. Permanent association of this equipment also permits related identification with permanent designations for carrier channels, signaling unit positions, and channel patching and monitoring jacks.

A variety of "packaged terminal" frames was designed to accommodate the needs of different central office terminal room arrangements and ceiling heights. The voice-frequency patching and monitoring jacks and associated voice-frequency transmission and noise measuring equipment may be omitted from the package, in the 11 foot-6 inch

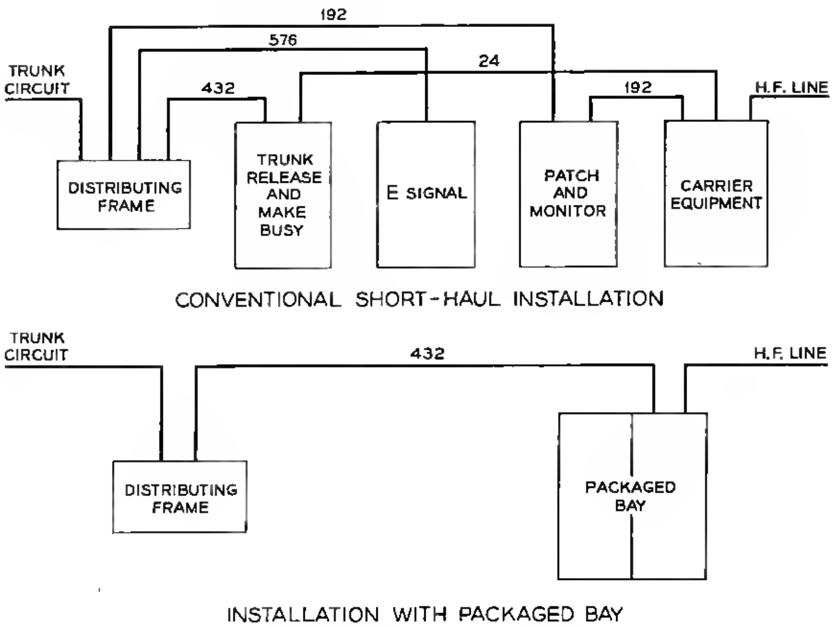


Fig. 3 — Comparison of installer cabling — number of conductors.

bays, where it is desired to locate this equipment in a centralized patching bay instead. Packaged terminal frames are designed in 11 foot-6 inch, 9 foot, and 7 foot heights.

V. PACKAGED 48-CHANNEL BAY EQUIPMENT

The 48-channel package is mounted on an 11 foot-6 inch double-bay cable-duct type framework, which is 53 inches wide and 12 inches deep. This package, shown in Fig. 4, contains the shelves for two carrier terminals, with a monitor and talk panel between them, located in the right side of the framework. The secondary carrier supply panel, from which all carrier frequencies for the two terminals are obtained, is located above the upper terminal. A 2000-cycle tone supply for testing EIF signaling units or a 2400-cycle supply for testing E2B or E3B signaling units is mounted above the secondary carrier supply when required and specified.[2] The power alarm and miscellaneous panel, located above the tone supply, includes power supply fuses for the terminal, signaling, and trunk release and make-busy equipment; alarm relays; means for mounting a restoral oscillator; and a terminal

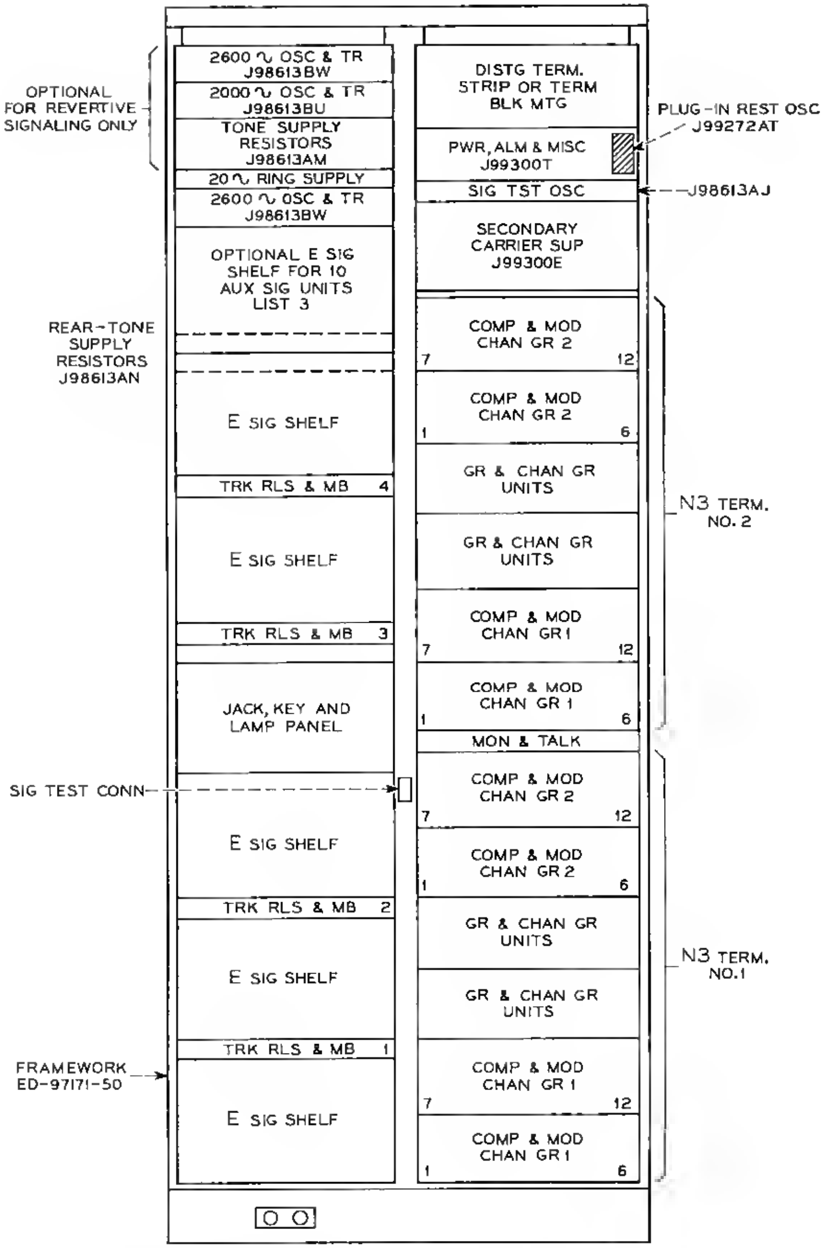


Fig. 4 — J99300A N3 carrier 48-channel packaged terminal frame (11 feet, 6 inches high) with patching jacks.

strip for the carrier line connections and miscellaneous connections to central office equipment. A distributing terminal strip assembly or a terminal block for terminating carrier line pairs may be located in the remaining space at the top of the right side, when required.

In the left side of the double bay, five (a sixth is optional) signaling unit shelves arc located for mounting the E-type signaling units. These aluminum die-cast shelves, each of which will mount ten units, are tbe same parts used in standard E-type signaling bays. Four trunk release and make-busy panels, one for each of the four 12-channel groups, are located between associated signaling shelves. The signaling unit connectors, although mounted on the signaling unit shelves, are shop wired to terminal strips on the trunk release and make busy panel. A jack, key, and lamp panel, which contains the voice-frequency patching and monitoring jacks, is mounted at a convenient height between a signaling shelf and a trunk release and make-busy panel. A 2600-cycle oscillator and transfer panel is located above the signaling unit shelves. Optional equipment, which may be located at the top of the left side, includes oscillator and transfer panels for two frequencies required for revertive signaling. This optional equipment for revertive signaling also includes a tone supply resistor panel. The standard 2600-cycle signaling tone supply is located on the rear flanges of the bay behind the top support of one shelf of signaling units and the bottom shelf of the row of signaling units above it. The bay also includes a signaling tone test connector and an optional 20-cycle ringing supply panel.

All interconnections between equipment in the "packaged frame" are made through shop formed bay local cables. Shielded wire is used for reduction of noise and crosstalk in carrier frequency leads and the more sensitive low level leads are placed in a local cable arm located in the center vertical cable duct. Most of the bay local cable connections are solderless wrapped to achieve manufacturing economy.

An additional 48-channel package is available in which the jack, key, and lamp panel is omitted and a terminal strip assembly is provided through which the voice channels are connected to a centralized patching bay located elsewhere. The few remaining keys and lamps associated with the alarm and control functions and tbe order wire telephone set jacks are mounted in a jack mounting located between the carrier equipment for the two terminals.

VI. PACKAGED 24-CHANNEL BAY EQUIPMENT

Packaged terminal frames for one N3 terminal (24 channels) are available on 9-foot and 7-foot double-bay duct-type frames. None of

the operational features of the 48-channel bay have been omitted. Each frame, as shown in Fig. 5, includes the carrier terminal equipment and units; VF patching and monitoring jacks together with miscellaneous jacks, lamps, and keys; an alarm, power and miscellaneous panel; a secondary carrier supply panel; E-type signaling unit shelves; signaling tone supply equipment; trunk release and make busy panels for each 12-channel subgroup; optional test tone supplies; a 20-cycle ringing supply; and a test connector for signaling test tones and battery supply for portable test sets.

The first 7 or 9-foot packaged N3 frame in an office (or the first of an added pair of frames) must include a secondary carrier distribution

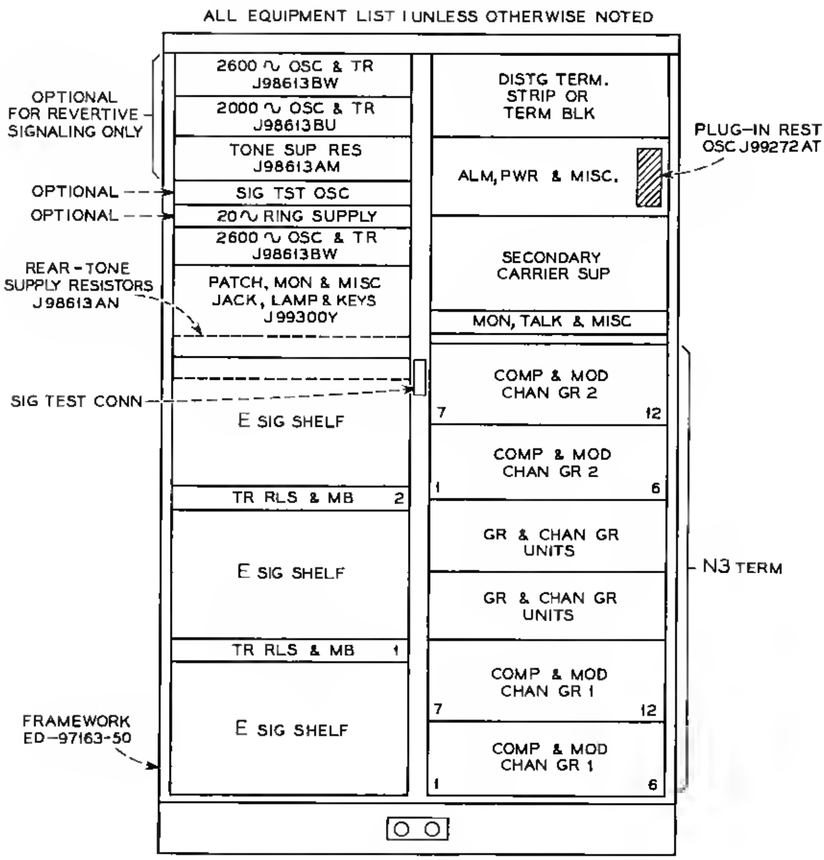


Fig. 5 — J99300D N3 carrier 24-channel packaged terminal frame (7 feet high) with patching jacks.

panel and an alarm, power and miscellaneous panel. Since these two panels are capable of feeding carrier frequencies and power to two terminals, considerable savings per channel can be realized by using this equipment to feed a second N3 packaged frame. For this reason, the second packaged 24-channel frames use terminal strip panels, in place of the carrier supply and alarm and power panels, for terminating interbay cables between the first and second packages.

VII. SIGNALING AND TRUNK CONDITIONING

It will usually be possible to locate all of the E-type signaling units associated with the carrier channels in the same shop wired package with the carrier terminal. Where auxiliary EIL-A and EIS-A units are used, they are matched with companion EIL and EIS units, respectively; each channel so equipped having two signaling units. Where these auxiliary units are used extensively, some additional unit mounting facilities may be required outside the shop wired package.

As noted earlier, the basic 48-channel packaged frames provide for mounting 50 E-type signaling units. An optional shelf may be added within the packaged frame for ten additional signaling units where the use of EIL-A and EIS-A units requires the additional space. In those cases where a total of more than 60 E-type signaling units will be associated with the 48 carrier channels, a signaling shelf is provided at a location outside the packaged frame and installer wired to the terminal strips on the trunk release and make busy panels in the terminal frame as required.

The 24-channel packaged frames provide mounting space for a maximum of 40 E-type signaling units in the 9-foot frame and 30 units in the 7-foot frame. Additional units can be accommodated by use of a supplementary signaling shelf provided at a location outside of the packaged frame.

The signaling shelf positions and associated trunk release and make-busy panels are wired to accommodate all currently existing codes of E-type signaling units. The optional connections for the various signaling unit and trunk circuit combinations are accomplished by wire wrapped connections at the terminal strips on the trunk release and make busy panels. Installer wired cabling to the distributing frame, for the 24 or 48 channels, is also connected to the terminal strips on these panels and includes connections for all optional choices of signaling unit codes. Arrangements are included to bypass the signaling unit connections for direct connection of the carrier channel to the distributing frame, if desired.

Either the 4-wire terminating sets incorporated in some E-type signaling units or separate 4-wire terminating sets located in other bays may be used with N3 carrier channels.

VIII. TRUNK RELEASE AND MAKE-BUSY PANELS

The trunk release and make-busy panel operates under control of the alarm and restoral unit to process the associated trunks during carrier failure and upon subsequent restoral. One panel is provided for each of the two 12-channel groups in an N3 terminal. When a plug-in alarm and restoral unit is provided for each of the two 12-channel groups of an N3 terminal, each trunk release and make-busy circuit operates independently of the other. This arrangement provides maximum circuit protection. Alternatively, one alarm and restoral unit can be used in each N3 terminal to control the two trunk release and make-busy units associated with the terminal. While this latter arrangement does not protect against failure of the channel group modem or frequency correcting units in one of the two 12-channel groups, it will be satisfactory for many applications. For most trunk and line circuits, the functions performed by the trunk release and make-busy circuits are as follows:

(*i*) Conditions the associated trunk or line circuit of an electromechanical switching system to disconnect the busy message trunk circuit, stop subscriber charges, and prevent subsequent trunk seizures during the alarm interval.

(*ii*) Provides alarm indications to a No. 1 electronic switching system which will then make idle trunks busy, disconnect and "make-busy" trunks in the pulsing condition, prevent subsequent trunk seizures, stop charges on calls in progress, release calling and called subscriber lines.

(*iii*) Registers each carrier failure experienced by a channel group on a unidirectional basis; that is, the failure is registered only at one end of a system to facilitate maintenance.

(*iv*) Automatically restores alarms and trunks to normal, at both terminals, under control of the alarm and restoral circuit, when transmission is restored to normal.

The specific circuit functions performed by the trunk release and make-busy circuit for each message channel differ widely in accordance with the E-type signaling unit and trunk or line circuit assigned. To provide the requisite flexibility for channel reassignment without installer effort, separate blocks of terminals on a terminal strip are assigned to each of the 12 channels in a channel group. This arrange-

ment permits reassignment of a channel, which is accomplished with optional straps installed by maintenance personnel, without interrupting service on other channels. A plastic template which can be installed on the block of terminals associated with a channel is provided for each of the channels to indicate the necessary optional strapping required for a particular trunk circuit and signaling unit combination. The template also serves as a visual aid to check the strapping. A wide variety of templates is available covering most of the combinations anticipated for use witb N3 channels. Provision of a terminal strip, subdivided into blocks of terminals for each channel, eliminates two distributing frame appearances for each channel. The resultant reduction in office cabling simplifies the problem of meeting critical lead resistance limitations, reduces noise and crosstalk exposures, and achieves substantial economies.

The trunk release and make-busy panel consists of a fabricated steel framework which mounts on the wiring side of the bay and supports the following:

(*i*) A 2-inch mounting panel which is extended forward to the front face of the bay and is equipped with the control relays and a message register.

(*ii*) A terminal strip and associated fanning strip attached to hinged supports at the rear of the framework and arranged to rotate on a horizontal axis into a position which permits access to both sides of the terminal strip and to the wiring side of the relays and message register.

(*iii*) A small terminal strip having the optional strapping which permits the use of either one or two associated alarm and restoral units for each 24-channel terminal.

To facilitate wiring and assembly of shop-wired bays, the panel local cable is wired to E-type signaling connectors for each of channels 3 to 12 of the associated channel group. These connectors are later fastened to an adjacent E signaling shelf when the panel is mounted in the bay. Tbe panel terminal strip provides for connections, through the bay local cable, to signaling connectors for channels 1 and 2 at a more remote location in tbe bay. Space is reserved on the terminal strip for installer connections to three spare E-type signaling unit connectors and their auxiliaries which are occasionally required and may be mounted external to tbe packaged frame.

All interconnections between tbe terminal strip and the relays are included in a shop-wired panel local cable. The bay local cable and installer cabling connect to the normally exposed side of the terminal

strip and optional strapping is done on this side. This panel occupies 8 inches of vertical space on the rear flange of the bay uprights, utilizing the space behind an E-type signaling shelf.

IX. MISCELLANEOUS EQUIPMENT PANELS

One alarm, power, and miscellaneous panel is used in each packaged 11 foot-6 inch terminal frame and on alternate 7 or 9-foot terminal frames. This unit includes distribution fuses for the carrier terminals, signaling units, trunk release and make-busy panels, alarm, and miscellaneous equipment in the frame. It also includes the main -48 volt fuse and fuses for feeding $+130$ volt and -130 volt power over the transmission pairs to remote repeaters. A -48 volt filter is included since the signaling units require filtered battery. The panel provides a mounting and connector for the plug-in restoral oscillator which provides 2600-cycle tone for transmission tests of the carrier line made after a system failure and prior to restoration of service. The relays associated with bay alarm circuits and from which alarm indications are passed to the central office alarm system are located on this panel. The panel also includes a terminal strip for miscellaneous interconnections to equipment in the central office. The restoral oscillator is a plug-in unit and is not furnished as a part of this panel. This panel occupies three and one-half 2-inch mounting plate spaces and is mounted and wired in the shop.

A patching, monitoring, and miscellaneous jack, key, and lamp panel is provided in one version of the packaged 48-channel equipment and in the 24-channel packages. This panel is mounted and wired into the frame and provides the following:

(*i*) The 4-wire VF channel patching and monitoring jacks.

(*ii*) Transmission and noise measuring jacks, keys, lamps, and switches.

(*iii*) The 1000-cycle test supply jacks.

(*iv*) Interbay patching and testing trunk jacks.

(*v*) Alarm lamps for transmission failure indication and an alarm override key and lamp for each 12-channel group.

(*vi*) Alarm lamps and alarm release keys for power supply unit voltage alarms.

(*vii*) Jacks and keys associated with the 4-wire monitor and talk circuit.

(*viii*) Telephone set jacks for association with the N carrier order wire.

This equipment is arranged on a jack panel approximately 23 inches wide and either 10 or 13 inches high for the 24- and 48-channel packages, respectively. Permanent designations are stamped on the panel and designation strips are provided where operating company circuit designations will be required.

X. DOUBLE-BAY DUCT-TYPE FRAMEWORK

The newly developed double-bay duct-type framework, shown in Fig. 6, is used for all terminal packages. Its use, instead of single bay

Fig. 6 — Bay framework (front view).

framework, permits more efficient utilization of space and greater economy in the shop assembly and wiring of a package. A number of equipment items which must be in a package of any size can serve the double bay at no greater cost than for a single one.

This bay has five-inch deep uprights with wide flanges in front and narrow flanges in the rear. The uprights with their flanges form cable ducts at the sides and middle of the frame. Both front and rear flanges are drilled and tapped for mounting bay equipment. The narrow rear flanges afford access to the duct for shop wiring or installer cabling. With this arrangement, low-level leads can be placed in the middle duct where they are automatically shielded from noisy or high-level wiring in adjacent bays. High-level wiring and wiring not too susceptible to noise is located in the outside ducts of the same frame. The wide front flanges increase the duct space and also provide sufficient space for designation card holders on the uprights.

The bases of the frames include guard rails and commercial power outlets on both front and rear for ac supply to testing and maintenance equipment. The bases and upper sections of the frameworks are designed for ready attachment of tools to facilitate handling in the shop and in the telephone office during installation. The frame is also arranged for attachment of installers dolly trucks which permit wheeling the bay into place in an upright position.

XI. TERMINAL PLUG-IN UNIT DESIGN — GENERAL

Since it was anticipated that the demand for N3 carrier plug-in units would be relatively large, it was decided that the equipment should not be designed around existing hardware and apparatus if significant penalties were imposed on the design as a result. It appeared that development costs involved with new hardware and apparatus could be justified if the new designs would reduce manufacturing or maintenance costs per unit even slightly. Working closely with the Western Electric Manufacturing Organization, considerable effort was expended to make the designs as adaptable as possible to automated machinery.

The basic plug-in unit consists of a single-sided, glass epoxy, printed wiring board mounted in an aluminum die-cast frame. Fig. 7 shows a typical board, frame, and shield in their relative final positions.

The shield is mounted to the frame directly adjacent to the wiring side of the board so as to provide a ground plane between adjacent

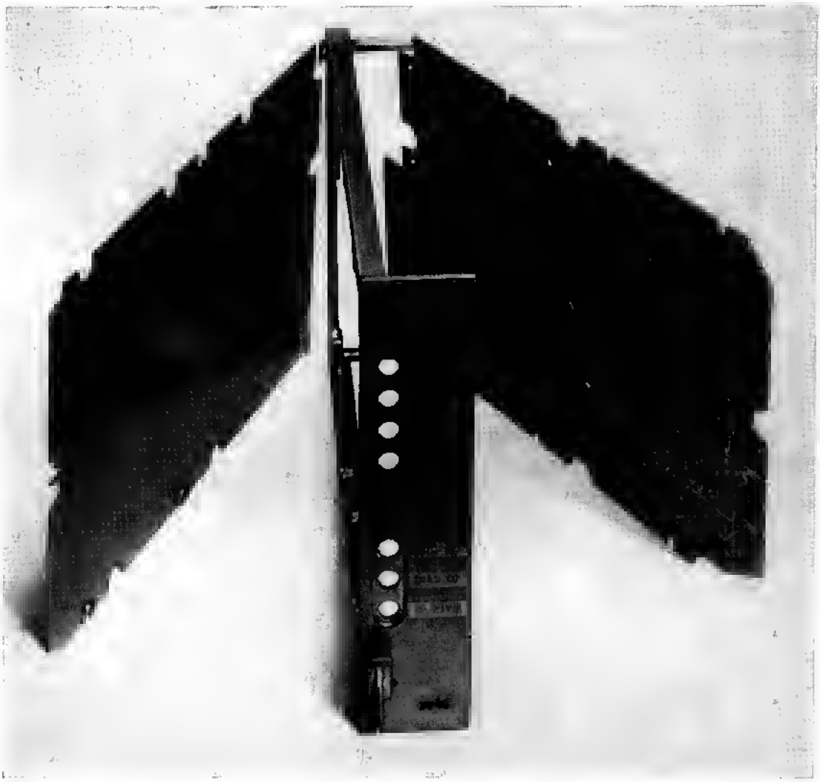


Fig. 7 — Basic frame, printed wiring board, and shield.

units for signal isolation. The shield is made from either aluminum or permalloy, depending on the amount of isolation required.

Both the printed board and shield are mounted to the frame with hex washer head thread-forming screws. These screws have a triangular shaped cross section designed to mount into cored holes in the frame. As the screw is installed, a thread is rolled in the frame without the formation of chips common to most self-tapping screws. The screws maintain a high residual torque after installation so that locking devices are not required. The washer head provides a fine bearing surface for mounting the board and shield without damaging them.

The frame die casting is of a very simple design, requiring very little post-casting machining because of the fact that no tapped holes are required. The basic frame has two surfaces on which the board and shield mount. The top and bottom frame rails provide the track

designed to slide into the bay shelf casting. The faceplate and rear posts of the casting provide protection to the components on the board when the assembly rests on the component side. The faceplate on the card frame extends the full width and height of a plug-in position and so provides a neat appearance when a shelf is filled with plug-in units. The modular space required by this unit is 8 inches high, 12 inches deep and 1¾ inches wide; thus, twelve units may be plugged into a single 23-inch shelf casting. The faceplate of the casting is provided with cored access holes to test points and potentiometers for in-service testing and maintenance. Each unit has a different faceplate due to different test points and adjustable components which appear there. These castings are all made by one basic die having interchangeable faceplate slides.

The only machining operation required on the basic casting is the sawing of a groove in the faceplate and lower frame rail for mounting a latch. Fig. 8 shows many of the pieces of hardware developed specifically for N3. Item 6 shows the latch assembly complete with spring and pivot pin. Although the latch resembles other latches used in plug-in equipment, the design of this latch is such that it is impossible to remove a plug-in unit without operating the mechanism. The angle of the hook is such that forces tending to dislodge a unit apply pure tensile forces to the latch, free of any twisting moment about the latch pivot point. The latch engages a hole in the shelf casting. When the latch is operated, the latch hook is released from the hole in the shelf and, in addition, the unit is pried forward to disengage the plug on the unit from the connector mounted in the bay.

Surface wiring is not only costly to provide but is a common source of manufacturing problems. To eliminate as much surface wiring as possible, any test point, potentiometer or switch which must be accessible at the faceplate is mounted directly to the printed wiring board at the faceplate edge of the board. Items 7, 1, and 9 of Fig. 8 show such parts which were designed for the N3 system.

The test point, shown as Item 7 on Fig. 8, was developed for use in the N3 carrier system. Two electrical connections from the test point are made with the printed wiring board by tabs which are clinched and soldered to a wiring path. To keep from stressing these electrical connections during probe insertion, two plastic tips protrude through the board and are headed over on the wiring side. The barrel of the test point is made from beryllium-copper, ¼ hard so as to provide a reliable contact. The tabs of the connector are made from relatively soft brass, welded to the barrel, so as to allow clinching without frac-

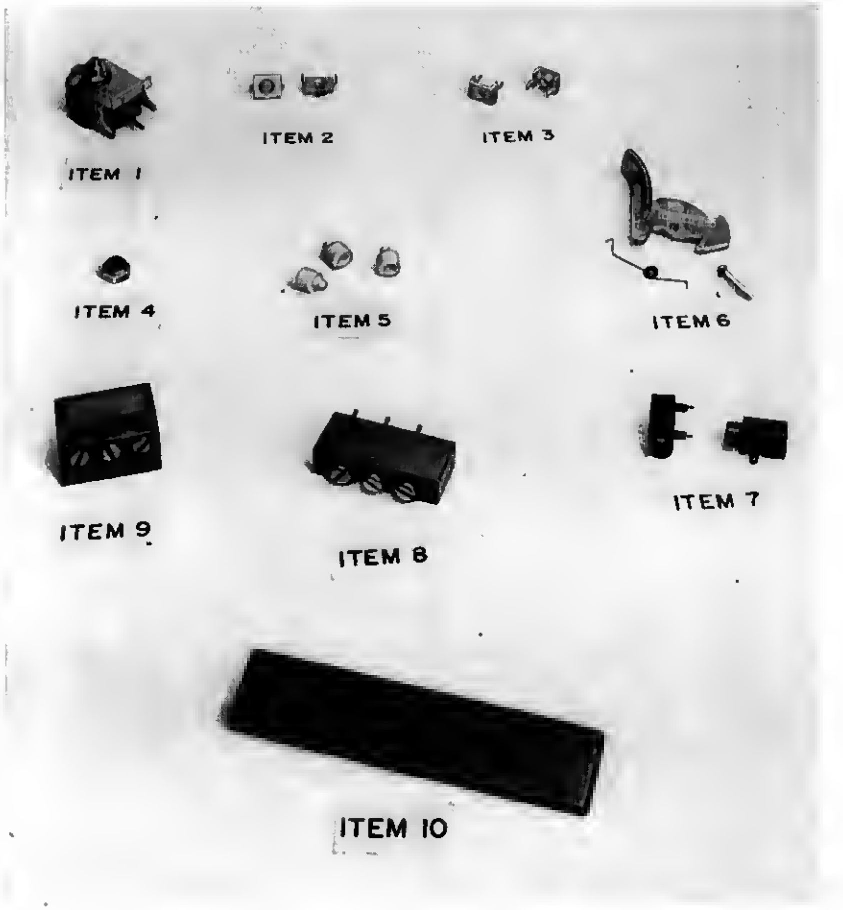


Fig. 8 — Plug-in unit hardware.

ture. The plastic surrounding the barrel of the test point protrudes through holes in the faceplate so that the test probes will not short to the casing during testing.

The potentiometer, shown as Item 1 of Fig. 8, was designed for N3 use. Access to this adjustment is obtained by reaching through a hole in the unit faceplate with an ordinary screwdriver.

The switch, Item 9 of Fig. 8, was designed to provide a component which, like the test point, mounts to the printed wiring board and protrudes through the faceplate. The switch presses into a cut-out on the front edge of the printed wiring board. Electrical connections are made

via the wires which protrude through the plastic block and bend so as to pass through the printed board where they are soldered to land areas. Item 8 of Fig. 8 is the same basic type of switch as Item 9 except it is made to mount internal to a unit directly on the printed wiring board without front access.

The filters and equalizer networks used on the N3 plug-in units are all housed in cans and are moisture resistance sealed where necessary. Two separate methods of electrically connecting these networks are employed — soldered type and mechanically attached type. The soldered type has electrical terminals and studs located on the mounting surface of the can. The terminals and studs protrude through holes in the printed board. When installed, the electrical terminals are soldered to land areas and the filters are mechanically held with elastic stop nuts mounted on the studs. The nuts generally bear against electrically grounded printed land areas so as to provide an electrical ground connection to the studs and, hence, to the cans.

Mechanically attached networks are those which are intended to be mounted or easily changed for maintenance in the field. For these units, it is desirable that no solder connections be required and that they be mounted without removing the metal shield from the card frame. Items 2 and 3 of Fig. 8 show piece parts designed to serve the function of a nut, tied electrically to the circuit, yet accessible from the component side of the printed board. Item 2 mounts on the wiring side of the board while item 3 mounts on the component side of the board. Both nuts are clinched to the board and soldered to land areas on the wiring side. The method in which they are used will be shown later.

The shield has such a large span and is located so close to the wiring side of the board that some provision to keep the shield away from the solder connections is necessary other than mechanical fastening to the frame at its edge. Items 4 and 5 of Fig. 8 are two parts designed for this purpose. Item 4 is an elastic stop nut which is used for mounting soldered type filters. The nut has a nylon insert which extends high enough to provide the necessary clearance between the board and shield, the nylon surface being higher than any solder mass. Where filters are not used, a nylon part (item 5) is snapped into a hole in the board from the wiring side to provide an insulating spacer.

With the exception of the power supply unit, all N3 plug-in units employ a printed wiring type of connector. The male portion of the connector consists of gold-plated printed wiring contacts on a portion of the printed wiring board which extends beyond the frame casting in the rear. Item 1 of Fig. 9 shows both the connector portion of the

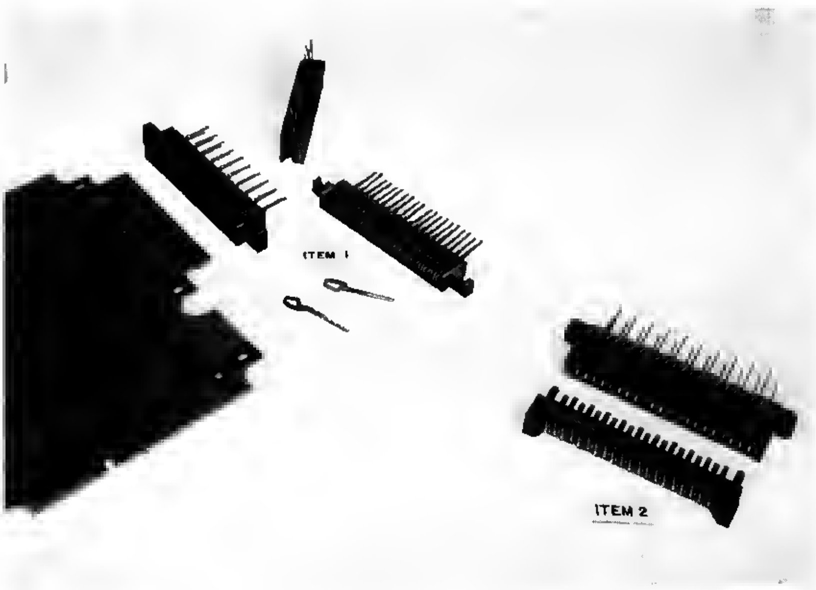


Fig. 9 — Plug-in unit connectors.

printed wiring board and the connector which mounts in the bay. As can be seen from the various cut-away views of the female connector, each tab has two pretensioned surfaces which wipe against the conductor path for a reliable connection. At the point where the surfaces touch the path, precious metal buttons are welded to the spring. This precious metal, wiping against the gold-plated land area, provides very low contact resistance. These connectors are mounted to the bay with a specially designed shoulder screw which provides the necessary float for alignment.

The power supply, due to its large current flow, requires a heavier contact than that provided by the printed wiring connector. For this purpose, the two part connector shown as item 2, Fig. 9 was used. The item 1 connector was designed specifically to meet the needs of the N3 carrier system.

Item 10 of Fig. 8 shows a flexible plastic protective cover which is placed on the connector portion of the printed wiring board before leaving the manufacturing area. This throw-away cover protects the gold-plated tabs from damage during handling and shipment. Since the connector tab portion of the printed wiring board is not protected by the frame, glass epoxy material was chosen for the basic board because

it withstands impact without damage much better than phenolic materials. The use of glass epoxy material was also found to be necessary for resistance to shock and vibration, since the apparatus mounted on these large boards is sometimes beavy and produces large stresses on the boards when vibrated or shocked.

The module height of the basic plug-in unit was chosen to allow the compandor, modem, and double-channel regulator units (large volume production units) to be of simple design for low manufacturing cost. In these designs, all components are placed on the main board. Some of the group units had too great a component density to allow all of the components to be placed directly on the main board. In these cases, a slave board, Fig. 10, is used. Two piece-part clips were designed to hold the edge of the slave board and provide stability. The clip is soldered to the slave board and also, after clinching, to a printed area on the main board so that the clip can serve as a conductor path connecting these boards electrically as well as mechanically. The components are mounted to the slave board in the manner shown in Fig. 10. Note that the pigtails of the components themselves are bent in a manner such that they serve as the electrical connection between the slave board and main board.

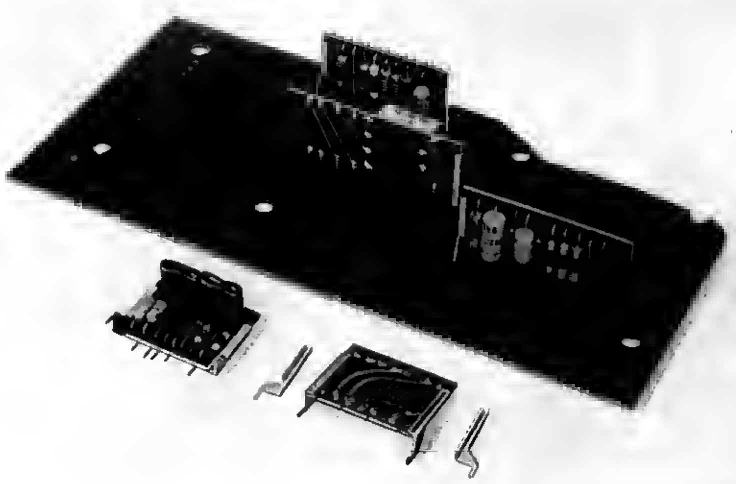


Fig. 10 — Slave board technique for obtaining high component density.

XII. SPECIFIC PLUG-IN UNIT DESIGNS

Several of the plug-in units will be discussed. In some cases the discussion will use specific units merely as examples to discuss general design principles whereas in other cases units will he discussed because of their unique design features.

Fig. 11 shows the component side of an early model of an N3 compandor unit. Some of the special hardware items developed for N3 are easily seen. The test points and potentiometer which mount to the hoard, accessible from the faceplate, are located at the faceplate end of the hoard. Terminal ⋕1 of the connector is externally wired to a frame ground. To connect frame ground to the unit frame and shield, the hoard mounting screw in the lower right-hand corner of each plug-in unit mounts through a specially developed terminal which is clinched and soldered to connector tab ⋕1. The mounting screw, bearing against this terminal, transfers the ground from the connector to the frame and from there to the shield via the shield mounting screws.

The compandor circuit, containing a compressor and expandor circuit, is laid out on the hoard so that there is adequate electrical isola-

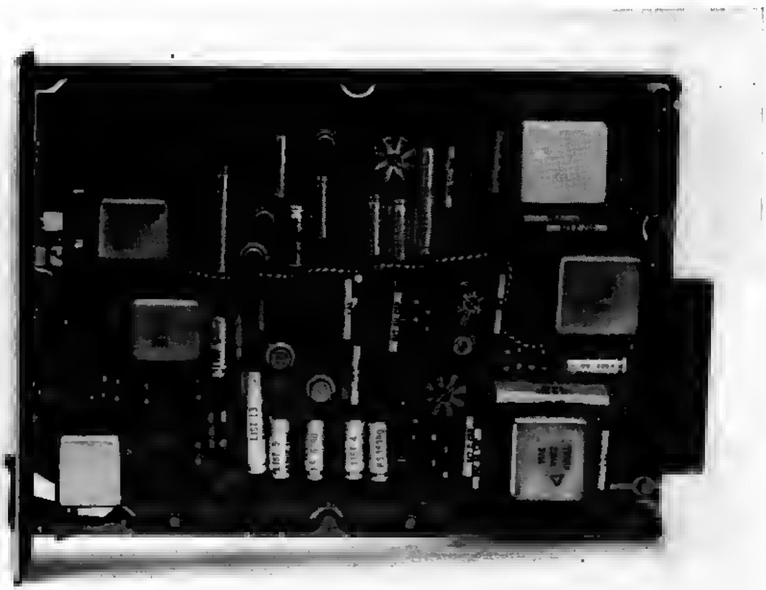


Fig. 11 — Compandor unit.

tion between these two circuits. Not only are the two functions physically separated but paths carrying low-level signals in the compressor circuit are spaced as far as possible from paths carrying high-level signals in the expandor circuit and vice versa. This principle was adhered to on all units having two-way circuits. Even the ground patb common to both portions of the circuit was kept separate on the board and made common only at the connector end of the board. Some units even have completely separate ground paths so as to prevent any possibility of local currents causing crosstalk interference.

Note tbat all of the components of the same type are mounted on the same bending centers in order to reduce the number of insertion machine positions required in the manufacturing area. Most tubular components lie in the same plane not only to make insertion by present type machines relatively easy but also to make the job of insertion compatible to fully automated machinery if and when it is used.

Two twisted pairs of surface wire were required in the compandor in order to meet stringent requirements on crosstalk. In many cases the wiring pattern became so involved that paths were required to cross on the printed wiring side of the board. This crossing is done with pieces of bare wires which are treated exactly as components from a manufacturing point of view. All such bare wires are of the same length so that they may all be inserted by the same machine. Although small details such as this may seem quite trivial, they are really very significant in view of the fact that these units will be manufactured in great volume.

Tbe cbannel modem unit, Fig. 12, demonstrates the two basic types of filters and networks used on N3 plug-in units. The two filters are tbe bandpass filters required to select a specific 4-kHz signal from the spectrum of 12 channels, one filter for each direction of transmission. The filters are completely attached to the unit from the component side of the board since these filters may be installed or replaced in the field. Since each of the 12 modem units requires different filters, a single modem unit, less filters, is provided to the field along with the required filters. This principle is also used for the pick-off filters of the double-channel regulator unit. The mechanical mounting of these filters is accomplished with the specially designed nut discussed previously. Screws having captive lock washers are used for mounting the filters to assure a good electrical connection between the filter and the path to which the nut is soldered. Since these filters contain very sensitive crystals, and inductors operating at very high impedances, they are moisture sealed. Any attempt to provide a method of attaching

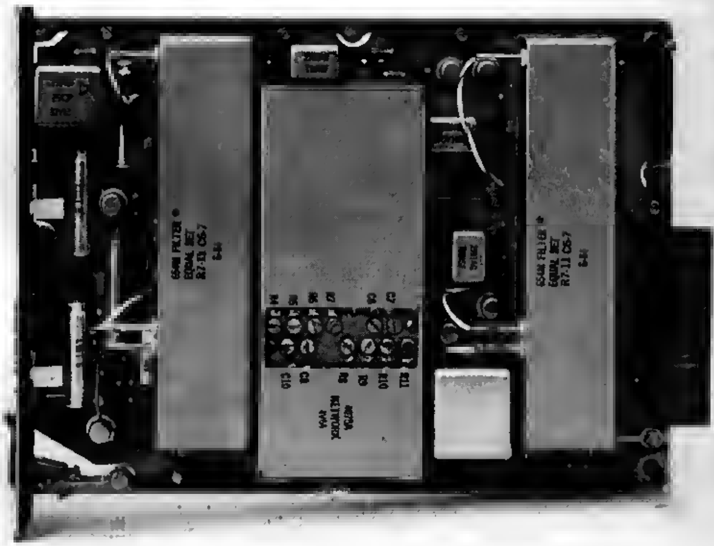


Fig. 12 — Modem unit.

leads to the electrical terminals which puts excessive stress on these terminals has to be avoided in order to maintain the seal integrity. A study of the tolerances involved in designing hardware for this purpose indicated that it would be best to use flexible wiring for the connections. But, since soldering was not desired, a special gold-plated connector was coded which would be soldered to a wire from the board and would be pressed on to the filter terminals. Gold-plated connectors and filter terminals assure low contact resistance.

The network located in the center of the board is an equalizer network which works in connection with the bandpass filters to achieve the desired bandpass characteristics. Since there are twelve filters of different frequencies used on channel modem units, the equalizer characteristics may have to be different for each of the twelve channels. All of the required components are placed in this single can which is soldered into the board during manufacture. The installer matches the equalizer to the particular set of filters used by turning down the prescribed set of shorting screws. The particular screws which require turning down are designated on the filters.

The high group receiving unit, Fig. 13, demonstrates the complete

Fig. 13 — High group receiving unit.

absence of wires on the component side of the board. The slope adjust switch and test points are all mounted on the printed wiring board and protrude through the faceplate so as to be accessible to the craftsman without removing the unit from service. Four slave boards are used to provide high component density. The slave board is treated just as any other multileaded component.

The smaller of the three cans on this board is an equalizer providing partial slope equalization for the N line. Since line frequency characteristics vary, this equalizer must be selected by the transmission engineer to match the line. For this reason, this can is designed to be mounted in the field rather than in the manufacturing shop. Unlike the bandpass filters used on the modem unit, this equalizer is not a moisture sealed unit and it was possible, by using the two special nuts described previously, to mechanically and electrically mount the can to the board with screws.

The alarm and restoral unit, power supply unit, combining and switching unit, and line terminating unit are shown in Figs. 14, 15, 16, and 17, respectively. These units are shown not because they represent typical N3 plug-in units but rather because they have features peculiar to themselves.

Fig. 14 — Alarm and restoral unit.

Fig. 15 — Power supply unit.

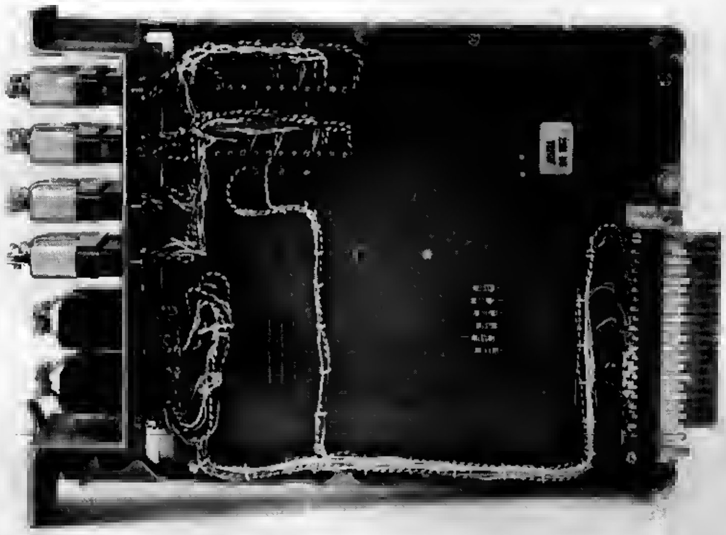


Fig. 16 — Combining and switching unit.

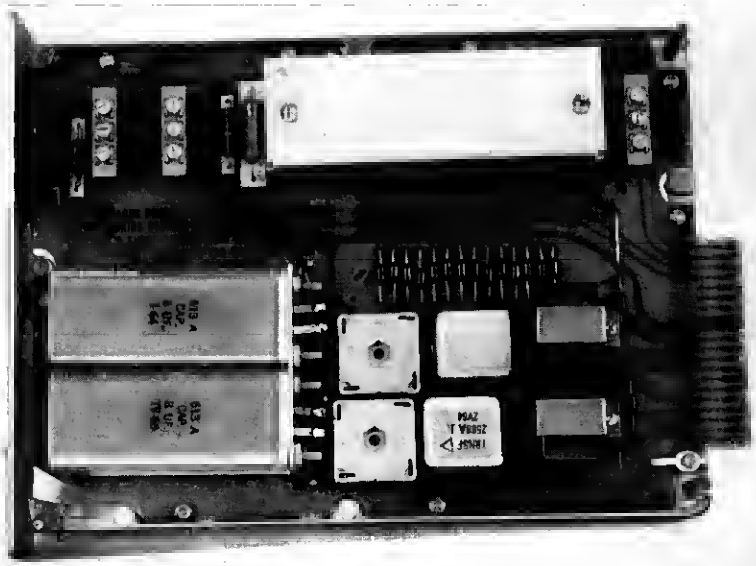


Fig. 17 — Line terminating unit.

The alarm and restoral unit, Fig. 14, uses 9 miniature relays. The amount of cross-connecting wiring required between relays was so great that many wires were required in addition to the printed paths. Slave boards, containing only bare wires instead of components, provided a method of running paths across the main board on the component side without using surface wires. A large amount of power is dissipated in one resistor on this unit. The resistor is mounted in a U-shaped metal shield at the rear of the unit so as to radiate the heat out the back of the bay where it will have negligible effect on the temperature rise of the unit. The large electrolytic capacitor, key, and lamp, although usually mounted directly to the casting, are mounted in this unit on special brackets which mount directly to the printed wiring board.

The power supply unit, Fig. 15, is shown because of its unusual construction as compared to the other N3 plug-in units. Since this unit required two modular spaces and since its components are rather large and bulky, it is made of a fabricated housing with most of the components mounted directly to the housing. The regulator circuit is partially contained on a printed wiring board mounted within the housing. This unit requires many loose wires due to the type of construction. Since these wires are contained within the housing, they are protected from damage related to handling.

The combining and switching unit, Fig. 16, uses two connectors for connecting to the bay wiring, one of the printed wiring type and one of the type used on the power supply unit. The resistors and hybrid coil on the printed wiring board provide the combining and splitting functions in the transmitting and receiving paths of the group units. Six female connectors, equipped with male shorting plugs, are located on the faceplate of this unit. Two connectors are provided for each of the group transmitting, group receiving, and power supply units. These connectors are used in conjunction with the switching set to permit in-service replacement of degraded group and/or power units.

The line terminating unit, Fig. 17, is shown to demonstrate how line treatment (build out, simplexed power feed, and surge protection) is accomplished. The two plug-in plastic cases in the lower right-hand corner are span pads to provide the required loss to the transmitting and receiving cable pairs. The screws, three sets of three each, provide the necessary means of sending power down the line for sealing non-soldered cable splices or powering repeaters from different local battery voltage supplies for different repeatered line requirements. The large heat shield contains a power dropping resistor which, depending

on the amount of simplexed power required, may dissipate between 0 and 11 watts. This heat is directed away from the unit and towards the shelf castings so as to keep the temperature rise of the unit to a minimum.

XIII. SWITCHING SET

The switching set (Fig. 18) is used in connection with the combining and switching unit to provide in-service switching of either a group transmitting unit, group receiving unit, or a power supply unit. Since these units can become degraded without complete failure and since they handle 24 voice channels, it is desirable to be able to replace them with new units without interrupting service. Upon removing one of the two paralleled power connector shorting plugs on the combining and switching unit, a power cord from the switching set is plugged into the

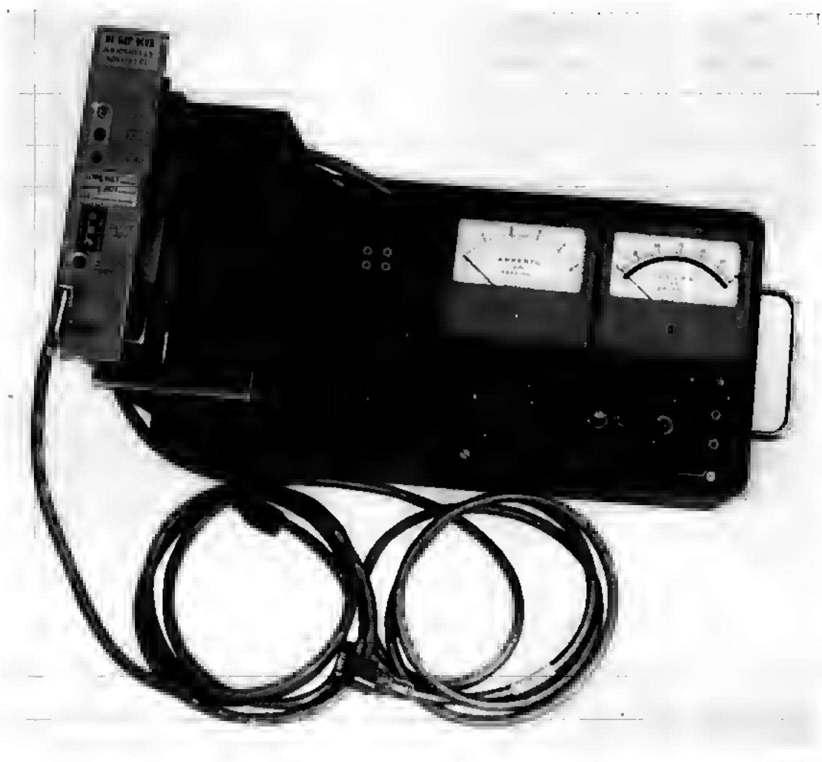


Fig. 18 — Group and power unit switching set.

vacated connector to supply power to the switching set. An alternate unit of the type to be replaced is plugged into connectors in the switching set (in Fig. 18, a high group receiving unit is shown being plugged in). To switch a group unit, a transmission cord from the switching set is plugged into the appropriate group unit connector on the combining and switching unit from which a shorting plug has been removed. After equalizing the output signals of the alternate and in-service units by use of gain controls on the switching set, the second shorting plug on the combining and switching unit may now be removed so that the bay service can be switched to the alternate unit. The regular unit may now be replaced by a new unit which is switched into service by reversing the procedure used to take it out of service. To switch a power supply unit, the procedure is similar to that used for switching a group unit except in this case the switching is accomplished by increasing the voltage of the alternate unit until it assumes the full load of the bay equipment. By switching in this manner, negligible "hits" will be experienced.

In addition to switching the above mentioned units, the switching set also serves as a test stand for the power supply unit to allow checking voltage of output, regulation, ripple voltage, and alarm cut-in points. The alarm cut-in points and voltage output may be adjusted while the unit is in the switching set.

The mechanical design of the switching set is a very simple fabricated box construction with all of its circuitry contained within the box. Most of the features of the switching set are obvious by referring to Fig. 18. The alternate unit wiring is not accessible when it is plugged into the set. This is a desirable feature in order to prevent tampering with the circuit when it is in service. The switches which actually transfer the load from the main to the alternate unit and vice-versa are protected to prevent their being accidentally thrown. In the same way that the power supply unit required a "beavier" connector tban the other plug-in units, a "heavier" connector is used for switching the power supply unit which explains why two different connectors are used for plugging the switching set into the combining and switching unit.

XIV. TERMINAL TEST STAND

The terminal test stand, Fig. 19, is used to field test most of the N3 carrier plug-in units on an out-of-service basis. The two cords and printed board plugs are placed in the bay to extend the bay connectors down to the connectors in the test stand. Two cords are required since

Fig. 19 — Plug-in unit terminal test stand.

some tests require two different units to be tested at the same time. The actual tests which are performed on the test stand are too numerous to be discussed in this paper. Each conductor of the test stand cords has a pin-type test jack appearance available on the stand for trouble shooting.

The terminal test stand is designed to be functional but not extravagant. Since the demand for the stand is estimated to be small, it is made completely of fabricated parts. As in tbe case of the switching set, the wiring for the test stand is completely enclosed within the body.

XV. CARRIER SUPPLY — GENERAL

The N3 carrier telephone frequency supply is common equipment that furnishes the modulating and demodulating frequencies for a maximum of 26 N3 carrier terminals. This requires the generation of 12 frequencies for voice-to-carrier frequency modulation of 24 voice channels, two channel group modulating frequencies and a group

modulating carrier frequency. An additional modulating frequency for the proposed N3 system to L system group conversion (N3-L junction) is also provided.

Since the final connection of the generated carriers at precise levels to their points of use could require wiring of 1482 pairs, a complex distribution problem is encountered. Economic considerations require that a maximum of the distributing connections be made in the manufactured product with as few connections as possible made at the installation site.

The carrier supply is the only source of modulating and demodulating frequencies for an N3 terminal. It must be used in a small central office where only a single terminal is used as well as in locations requiring its maximum capacity of 26 carrier terminals. Because as many as 624 channels might depend on this supply, the system must be reliable. Whereas reliability is the prime consideration of the supply when used for 26 terminals, cost is of major consequence to the small installation which serves only one terminal.

Although the carrier supply will, in most cases, be near the terminal equipment, it may be located elsewhere in the office. The physical appearance of this piece of equipment should be compatible with that of the equipment it serves in order to aid the plant forces in associating the carrier supply and the terminal. This continuity of appearance is established by using the same die-cast unit frame and mounting shelf as used in the terminal equipment.

As outlined above, distribution, reliability, cost and appearance are the major design considerations in common equipment. The following description represents a solution to these problems for the N3 carrier supply, the mechanical arrangement of which is shown in Fig. 20. This figure indicates the relationship of the prime carrier generating and distributing equipment to the secondary distribution and carrier terminal bays.

XVI. FREQUENCY GENERATION

All of the frequencies distributed from the carrier supply are generated from a 4-kHz source.* Two different optional plug-in units provide the 4-kHz drive to the saturating inductor which creates the harmonics of 4 kHz. One plug-in unit contains a stable, temperature-controlled crystal oscillator (coded the 61A oscillator) for independent generation of the 4-kHz signal. The second unit is driven from a 4-kHz source

* A detailed circuit description is included in this issue by R. L. Haner and I. E. Wood, "Circuit Design of the N3 Carrier Terminal."

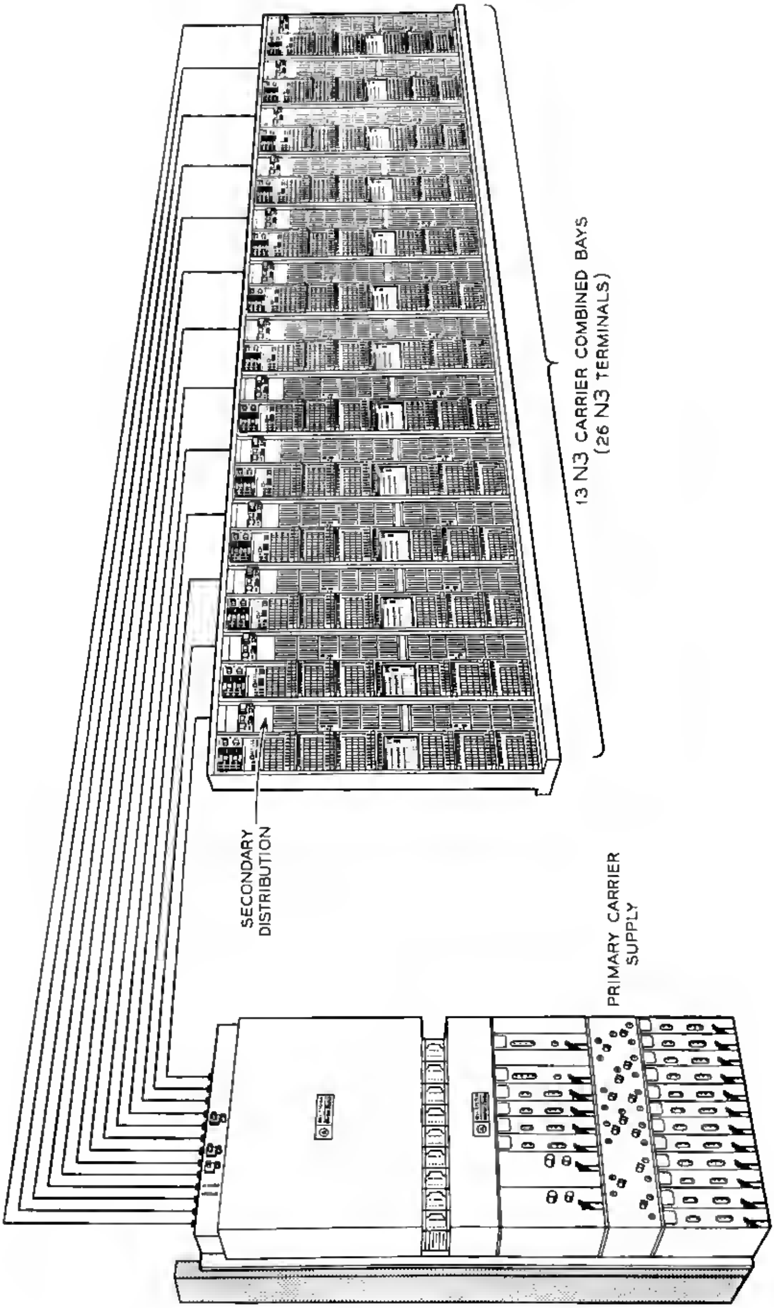


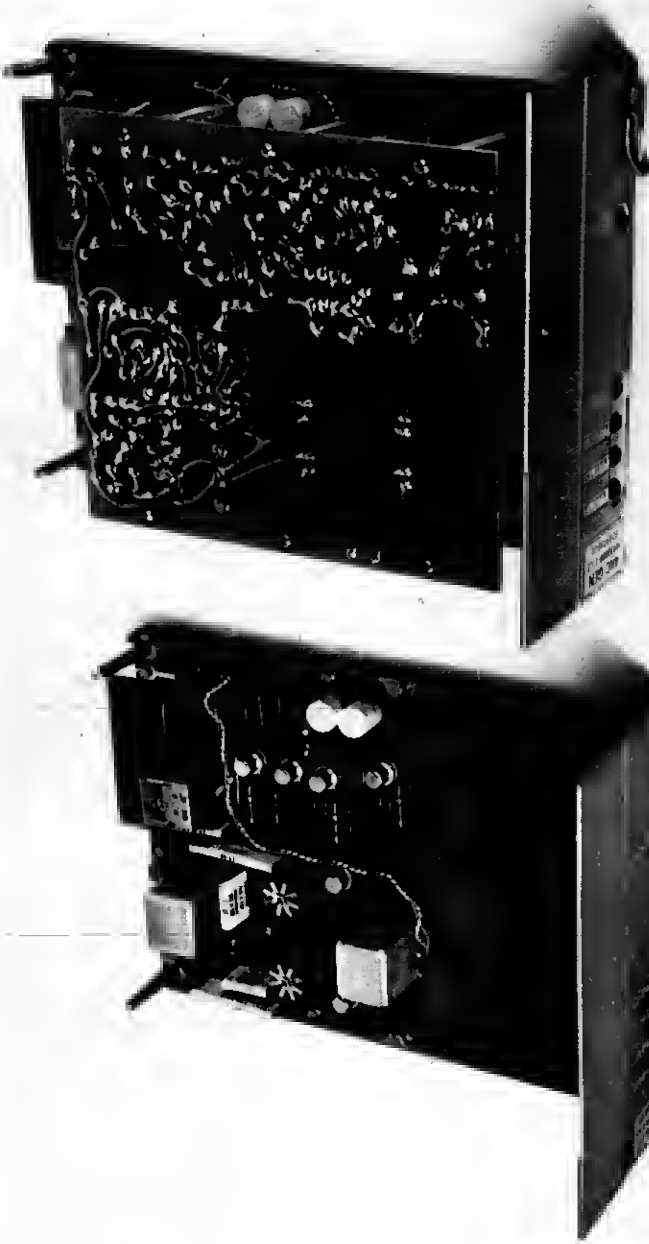
Fig. 20 — N3 carrier supply in relation to the carrier terminals it serves.

already available in the office. The harmonic generator creates the even and odd harmonics of 4 kHz in the required carrier range. Fifteen of these harmonics are selected by crystal filters. A sixteenth frequency for group carrier modulation (304 kHz) is generated in the doubler-amplifier from the 152-kHz tone selected by one of the 15 crystal filters. The filtered harmonic outputs are applied to limiting amplifiers which provide a constant output signal voltage determined by the regulated power supply voltage.

The 4-kHz generator plug-in units are constructed on a basic N3 modular plug-in unit frame with an additional modular face plate attached to provide the necessary height from the printed wiring board surface. Such an arrangement is necessary to accommodate the polyurethane plastic foamed oven of the 61A oscillator on the unit which provides independent generation of 4 kHz. Each type 4-kHz plug-in unit contains sensing circuits which activate alarms and control circuitry in case of excessive variations in oven temperature (when provided) or output voltage of the 4-kHz signal. Fig. 21 shows the two versions of the 4-kHz generator, (a) receives 4 kHz from an external source and (b) contains an internal 61A oscillator.

The harmonic generator and crystal filters necessary to select the required frequencies are positioned together on a single panel. The harmonic generator is driven by the 4-kHz generator and provides even $((2n)\ 4\ \text{kHz})$ and odd $((2n + 1)\ 4\ \text{kHz})$ products on two separate balanced output circuits. The odd and even filters are separated by being fastened to opposite sides of the mounting shelf to simplify the wiring of the assembly. Fig. 22 shows the 4-inch high housing, with and without its front maintenance panel, indicating the equipment arrangement of the completely enclosed harmonic generator and filters. All connections to this unit are made through a terminal block located at the back of the unit. External wiring from the unit to the associated equipment is run in shielded pairs to reduce office noise pick-up into these low-level circuits.

The frequencies developed by the harmonic generator and filters are applied to the input terminals of the dual amplifier plug-in units shown in Fig. 23. The dual amplifier units contain two identical voltage-limiting amplifiers. A built-in level sensing circuit monitors the output of both amplifiers and provides an output alarm indication if either amplifier is out of working limits. Two frequencies selected on the basis of circuit reliability and intermodulation considerations are applied to each dual amplifier and separately amplified through them. Seven dual amplifiers provide amplification of 14 frequencies by am-



(a) (b)

Fig. 21 — 4-kHz generator plug-in unit. ((a) for use with external source; (b) with 61A oscillator mounted in place.)

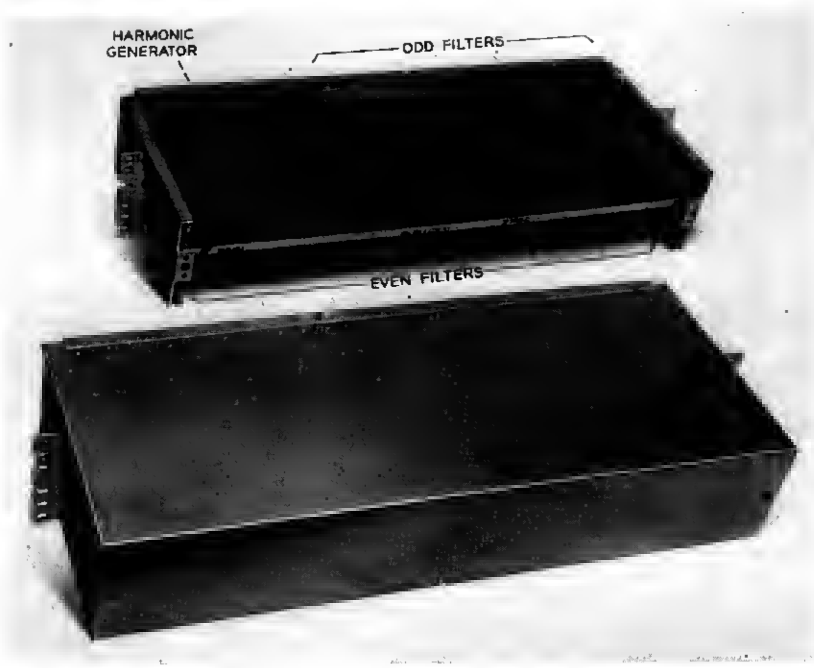


Fig. 22 — Harmonic generator and carrier filter panel shown with and without protective cover.

plitude limiting amplifiers and these outputs are applied as square waves to the primary distribution panel. The fifteenth and sixteenth frequencies (152 kHz and 304 kHz) require different treatment. The 152-kHz signal is applied to a doubler-amplifier, shown in Fig. 23, which is a plug-in unit containing a printed wiring board identical to that used in the dual amplifiers. The doubler-amplifier contains the two amplifiers that the dual amplifier contains; however, a doubling stage is provided in front of one of the amplifiers and the entire circuit is driven by 152 kHz only. The 152-kHz signal is amplified and appears on one output; it is also applied to the doubler stage to generate a 304-kHz signal which is amplified and appears at the second output.

All of the plug-in units are assembled on N3 die cast modular plug-in unit frames. The dual amplifiers are identical to each other and are completely interchangeable from one frequency position to another.

XVII. RELIABILITY

With the carrier supply providing carrier frequencies to many different terminals, the loss of 624 channels (which its total failure would

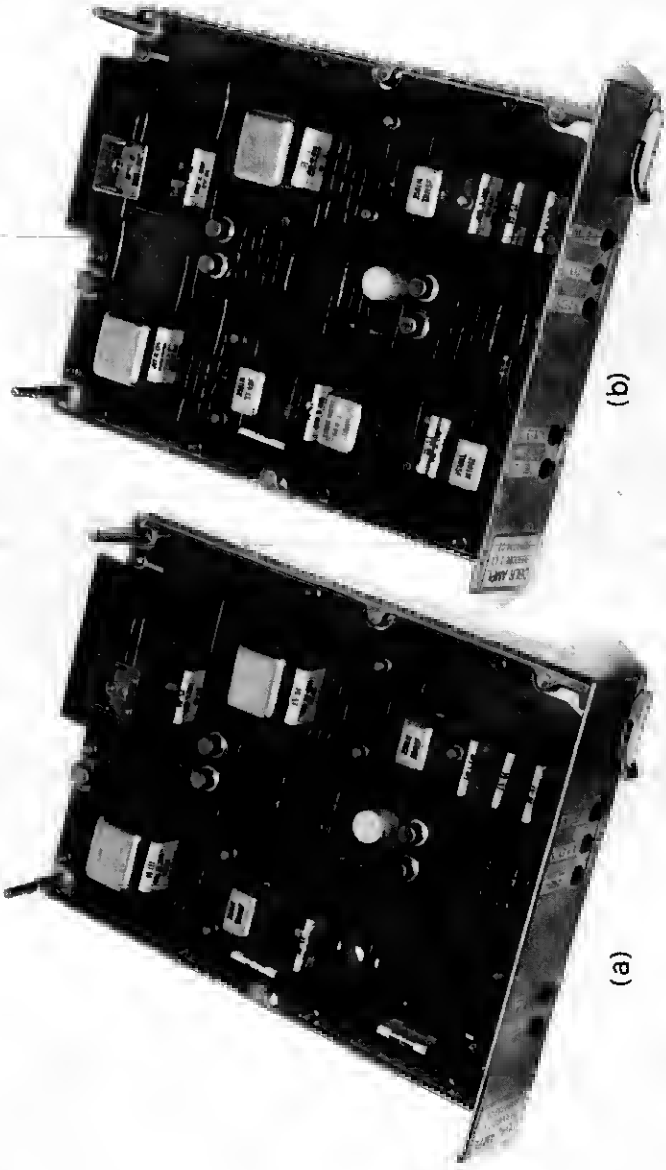


Fig. 23 — (a) dual amplifier; (b) doubler amplifier.

cause if it were fully loaded) could isolate many areas served by an office. This could be more adverse than the loss of 624 channels in a large office might indicate.

The carrier supply has been designed to allow as much choice as possible in the amount of protection to the carrier system for any particular situation. This has been accomplished in two ways. All of the alarm sensing and most of the logic for switching is included in the plug-in units themselves. The sensing features of each circuit required to operate the office alarms in case of failure (even though automatic switching is not required) is a simple arrangement that makes it possible to add the switching logic at very little cost. The second manner in which protection is accomplished is by providing two adjacent plug-in positions, one regular and one alternate, for each of the required plug-in units. Both positions are wired to the primary distribution panel through a control relay. Either position can be selected by a manual switch to have its output connected to the distribution panel; the unit in the other position acts as the automatically switchable spare for the manually selected unit in the event that this circuit fails. Either alternate or regular positions can be left empty as long as there is at least one of the correct plug-in units in either position for each of the required functions.

Table I indicates the pairs of frequencies that are assigned to the different dual amplifier positions. In addition to the units listed in this table the equipment is powered by a plug-in 48 volt dc to 21 volt dc converter whose failure would mean the complete loss of all generated carriers. This is the same power supply used in the N3 packaged terminals.

All active circuit components are mounted on the plug-in units mentioned. Filters, wirespring relays, and inactive components have generally been mounted on fixed panels and hard wired into the signal path. The exception to this rule in the entire carrier supply is in the secondary distribution panel (mounted in the packaged terminal frame) where the regulators for the transmitted carriers are active circuits that are wired in place.

A certain measure of reliability is attained merely by the use of plug-in units. This is not to say that because a unit is plug-mounted it is more reliable. Rather, even if more prone to failure, the plug-in unit is easily replaced and the circuit down time is therefore reduced. Of course, this premise is based on having adequate spares for the protection of the carrier supply. Admitting the necessity of having at least one spare of each type of plug-in component of a supply for re-

TABLE I — FREQUENCY ALLOCATION TO PLUG-IN UNITS

Unit	Frequency	Channels Affected on Single Terminal	Channels Affected on 26 Terminal
4-kc Generator	24 kHz	24	624
Double-amplifier	152 kHz 304 kHz	14* 24	338 624
Dual amplifier	168 kHz 280 kHz	14* 12	338 312
Dual amplifier	172 kHz 232 kHz	2 12	52 312
Dual amplifier	176 kHz 256 kHz	4* —	52 —
Dual amplifier	148 kHz 180 kHz	2 2	52 52
Dual amplifier	156 kHz 184 kHz	2 4*	52 52
Dual amplifier	160 kHz 188 kHz	4* 2	52 52
Dual amplifier	164 kHz 192 kHz	2 4*	52 52

* Since those frequencies marked 4 are transmitted carriers a loss of these carriers would affect 4 channels or 2 per channel group. Half the channels go open and the other half would have excess gain due to the operation of the double channel regulator. Similarly, the 152 and 168 kHz affect 12 channels in one group and 2 in the other.

liability, the spares can be stored in the alternate circuit positions so that they can be powered and their outputs monitored continually for defects and automatically switched to protect the working circuits.

Table I shows that a single spare of each type of plug-in unit, plus a power supply unit, can give automatic protection for most of the critical frequencies. Since the power supply is identical to that used in the terminal equipment, it can be stored in the carrier supply as an automatic switchable spare and be available on a plug-in basis in case of failure of a power supply in the terminal equipment. Likewise, the dual amplifier spare can be stored in the alternate position for 168 kHz and 280 kHz, as an automatically switched spare, and still be available on a plug-in basis for any other dual amplifier position in case of failure. When a unit is used in this manner the originally protected position does not have the switchable protection until a good unit is plugged into the spare position again. Whether a unit is in a regular

or alternate plug-in position, it is constantly monitored by its own sensing circuits. By plugging the spares into their automatically switched protection positions their status is always known by the display of indicator lamps.

The condition of plugged-in units is visually presented on a 4-inch switching and alarm panel. The relation of this panel to the plug-in equipment is shown in Fig. 24. In the figure, the regular (or minimum) number of plug-in units are discriminated from the optional alternate plug-in positions which are shaded.

The switches and lamps associated with each set of regular and alternate plug-in positions are located in proximity to the units they control and monitor. This places a lamp either directly below or above the particular unit whose condition it indicates. The switch is placed above or below and between the two units it controls and indicates the manually selected units by means by a line inscribed on the switch knob.

Lighted lamps indicate failure of a plug-in unit. If a unit is not plugged into position, the lamp associated with that plug-in position will not be illuminated. Likewise, if all units are plugged in and are in good working condition, the lamps will not be lighted.

Failure of a protected unit will result in an automatic switch to the protecting unit. The lamp associated with the failed unit will be lighted, and a minor alarm will be indicated. If even a momentary defect occurs in the unit in the position selected by the manual switch, it will cause switching to the protecting unit and will lock the selected unit from returning to active service. This provision is provided to prevent chatter switching of marginal units. The position not selected by the manual switch does not have this lock-out feature and alarm indications occur only as long as a unit is in a failed condition. A minor alarm will be sent, however, and will stay on until it is reset even if the trouble clears. This could create a problem if a marginal unit were located in a protecting position. Service would not be affected, however, and a close watch on the equipment would indicate the defective unit. The alternate position serves as an excellent check of the units capability to function in the circuit since the lamp associated with it will indicate its condition when the unit is plugged in.

If a unit which has no adjacent protecting unit fails, its associated lamp will glow and a major alarm will be indicated. The unit will not try to switch to the other position. This is true whether the other position is blank or contains a defective unit. If both units fail, the unit remaining connected to the circuit will be the one indicated by the position of the manual switch.

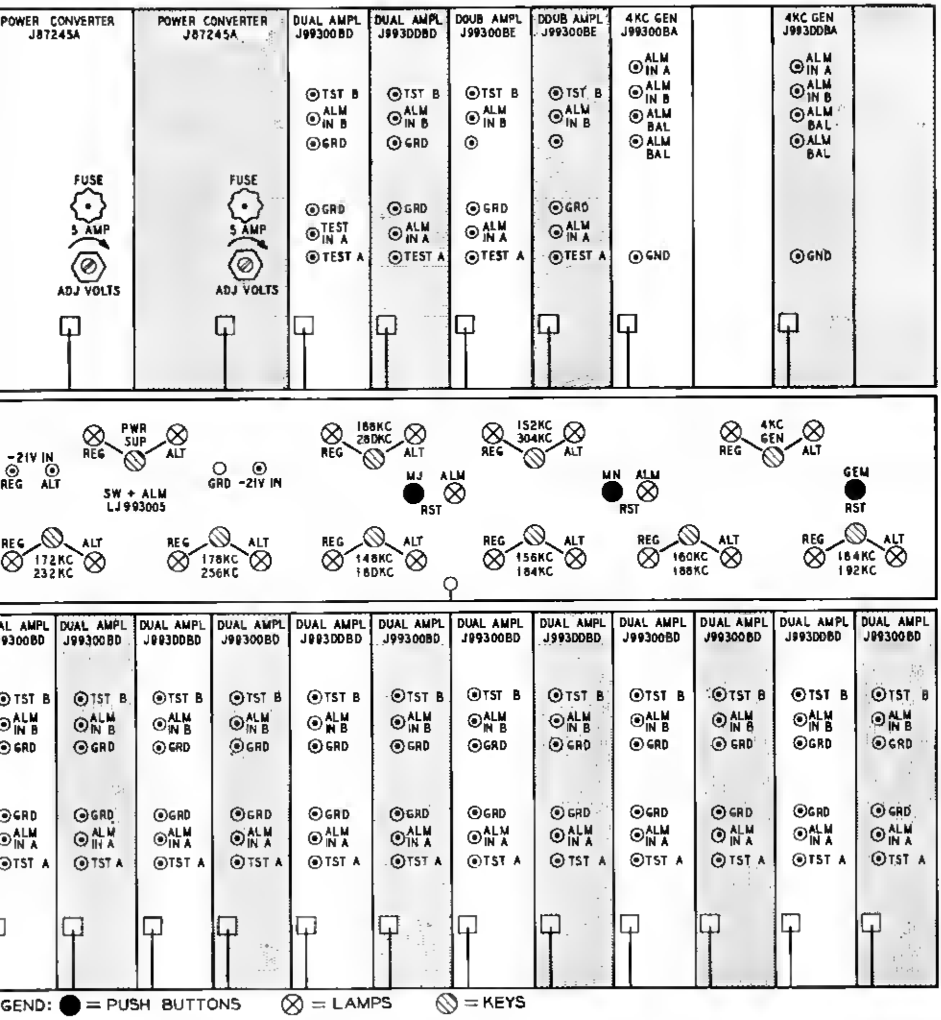


Fig. 24 — Switch and alarm panel in relation to plug-in units (alternate plug-in positions shown shaded).

All of the above functions are equally applicable to units in either the regular position or the alternate position; however, there is a preference for operating with units in the regular position. If −48 volt battery supply to the alarm circuit fails, all of the regular positions will be connected to the distribution circuit regardless of whether they are equipped with working units or not. Automatic switching of

all of the units except the power supply is done by transfer contacts on wire-spring type relays. Units not in the circuit are terminated in resistive loads. The power supply is switched by a mercury contact relay and the protecting power supply is always connected to a 50 per cent load to maintain its regulated output voltage within the required range to allow automatic switching.

The major and minor alarm indications are generated by bistable logic circuits which are triggered by an ac-coupled signal from a failed unit. An office alarm indication may be cut off at the switch and alarm panel prior to clearing the trouble condition on the panel itself by operation of the manually operated reset button. After being reset, the major and minor alarm circuits are capable of providing another office alarm for any additional trouble. The logic circuits for the major and minor alarms are packaged plug-in cards. Since they are switching circuits and are not as subject to component aging as analog circuitry and since they are not in "transmission" path, they are available for maintenance only by some disassembly of the switch and alarm panel.

XVIII. DISTRIBUTION

To supply 16 discrete frequencies from the primary supply to the exact location of each carrier terminal where they are needed entails a distribution of 57 pairs to each terminal as shown by the frequency disposition described in Table II.

Two N3 terminals are supplied in an 11 foot-6 inch framework;

Table II — Frequencies Required for Operation of One N3 Carrier Terminal

Freq. (kHz)	Channel Mod.	Channel Demod.	Trans. Cx	Freq. Correct.	Channel Group	Line Group	L-N3 Group
143	2	2					
152	2		2	1			
156	2	2					
160	2		2				
164	2	2					
168	2		2	1			
172	2	2					
176	2		2				
180	2	2					
184	2		2				
188	2	2					
192	2		2				
232					1		
280					1		
304						1	
256							4

therefore, the frequency distribution in a single bay requires wiring of 114 pairs. In addition, those pairs supplying carrier frequencies which will be transmitted over the carrier line require severe distance limitations between the terminal and the carrier supply or a mop up at the terminal since their output power is required to be within ± 0.05 dB of the normal operating power of -19 dBm.

In order to relieve wiring congestion, deliver the desired frequencies within the amplitude tolerance necessary, and relieve the installer of the large number of connections between the carrier supply and the terminal, a secondary distribution panel is provided in the terminal bay. This distribution position provides compensation for cable wiring losses between the primary and secondary distribution points. It also provides a place within the bay to fan out a single input of each frequency received from the primary distribution to the number of output pairs required for two terminals. Regulation of those frequencies for use as transmitted carriers is also done at this secondary location with the resultant advantage of lower losses in the shorter lengths of distribution leads through bay wiring to the terminals. A secondary carrier distribution panel which provides these features is shown in Fig. 25.

With this distribution arrangement the installer has only to connect

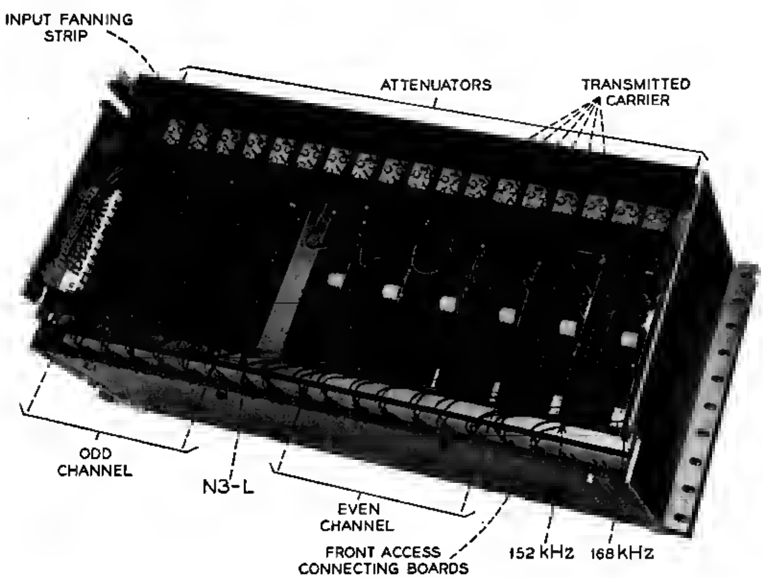


Fig. 25 — Secondary carrier distribution panel (rear view).

a single cable containing 26 pairs (of which 19 are used) between the primary distribution and the secondary distribution panels. All other distribution connections are made on shop-wired bays at the factory.

The secondary distribution equipment consists of a fabricated aluminum chassis which holds four die castings that provide the top and bottom of two shelves. The two die castings consisting of the top and bottom of the upper shelf are identical and provide evenly spaced slide positions for 19 printed circuit attenuator cards. The attenuator cards contain switchable balanced pads that provide 1.5 dB of total loss in 0.5-dB steps for compensation of office wiring losses. Pad selection is made by screw-down shorting adjustments on a plastic block mounted as a component on the attenuator card. The block is mounted to give installer access to the screws without removing the printed card. Connections to these printed cards are accomplished through solderless wrap terminals which are mounted on the edge of the cards and soldered to the printed wiring paths.

The installer clamps the office cable from the primary distribution unit to the side of the secondary distribution panel and dresses the pairs through a plastic fanning strip to the attenuator card locations. He then wraps each pair of conductors to the input terminals of the attenuator provided for each specific frequency. Each of the channel group frequencies (232 kHz, 280 kHz) and the group carrier frequency (304 kHz) are provided on two pairs from the primary distribution so that these frequencies are provided with two attenuators and distributed directly from the attenuators to the terminal circuits.

Although the die castings for the top and the bottom of the lower shelf are identical, the printed wiring boards for which these castings provide slides contain apparatus of different height, and the slide positions are not evenly spaced. The printed boards mounted in these slides provide the final distribution and isolation circuits for two terminals.

There are four different types of boards in the lower shelf to provide the required functions. Seven boards contain capacitors and fixed pads for distribution and isolation of eight outputs of each of seven frequencies. Four outputs of six of the boards are wired to each terminal and provide all of the odd channel ($(2n + 1)$ 4 kHz) modulating and demodulating frequencies. In addition, one of these boards provides four outputs to each terminal for the N3-L junction frequency.

Four boards contain capacitors and fixed resistor pads and provide four outputs of each of four frequencies. Two outputs of each of these boards provide modulating frequencies for the even ($(2n)$ 4 kHz) chan-

nels except for 152 kHz and 168 kHz. Two cards with six outputs of 152 kHz or 168 kHz provide the two outputs per N3 terminal for modulating at these frequencies and a third output per terminal for the frequency correcting circuit.

The only active circuitry in the distribution network is contained on six boards with four outputs each for use as transmitted carriers. A regulator and isolating pads are mounted on each of these printed wiring boards.

A total of 19 boards slide into the lower shelf. Shields made of preformed aluminum fit into slides between tbe printed wiring boards to decrease the crosstalk coupling between adjacent cards.

Connections to all of the boards are made through edge-mounted solderless wrap terminals which are soldered to the printed wiring paths. The terminals are positioned on the boards such that the terminals across the shelf line up in numbered rows and by board position. Ducts provided for fanning the connecting wire hold the boards from coming out of their slides. A duct can be loosened and moved out of the way in case a board has to be removed for repair.

All factory and installer wiring is on the installer aisle side of the equipment. The front, or maintenance aisle side of the equipment, consists of a blank surface 4 inches behind the front guard rail. Two printed wiring boards mounted under the secondary distribution panel provide an appearance of each modulating frequency at the front of the panel. It is anticipated that when arrangements are developed for alternate message and wideband data use of a portion of the carrier line bandwidth, the circuit which accomplishes the required switching may be mounted on the front surface.

Since the secondary distribution panel is mounted in the same bay as the terminal equipment and performs all of the necessary level control and distribution of frequencies to the terminals, the primary distribution has only to distribute the carrier frequencies to a maximum of 13 secondary distribution panels. The connection between a primary distribution panel and a secondary distribution panel is made by a 26-pair, aluminum shielded, polyethylene covered cable. Crosstalk coupling between the cable pairs and pair loss at the higher frequencies limit the separation between a primary distribution and a secondary distribution to 700 sheath feet of this cable. Provision is made for grounding the aluminum shield at either end of the distribution cable by means of a special clip.

The primary distribution panel shown in Fig. 26 has two basic functions. The first and more obvious is to provide for isolated distribution

Fig. 26 — Primary distribution panel (front view, cover removed).

of 16 frequencies to each of 13 secondary distribution panels. The second is to provide filtering of the square waves received from the limiting amplifiers, so that pure sine waves tones will be distributed.

The primary distribution panel consists basically of two similar printed wiring hoard designs. The input wiring to these boards is done at the factory and the distribution from the boards is directly to the installer connected cahle. As in the secondary distributing panel, all filtering and distrihution is done on the hoards and no additional wiring to terminals strips or other distrihuting means is required.

The smoothing filters are made up of components which cause their height to be greater than that commensurate with the number of distribution boards required in the space available. In order to provide for the filters within the space limitations, two boards were designed which allow the filter on one hoard to interleave with the adjacent board. A representation of this is shown in Fig. 27.

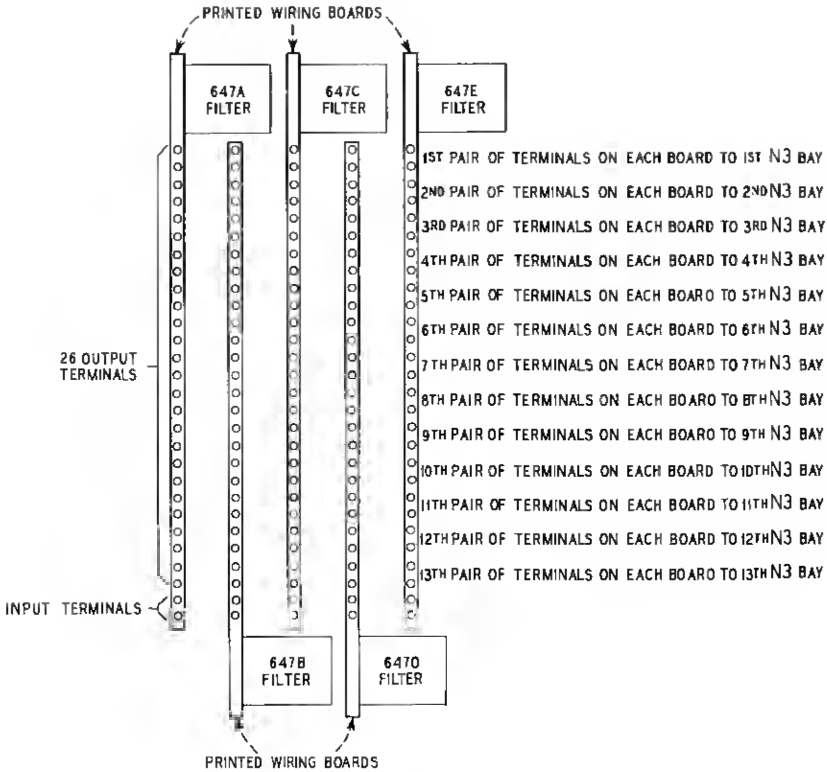


Fig. 27 — Section of primary distribution panel showing mechanical interleaving of smoothing filters and terminal assignment.

Each of the channel frequencies and the N3-L junction frequency is distributed 13 times from an individual board. The balanced low impedance output filter on each board is tuned to the particular frequency that it is to distribute. The series output capacitor of each of the filters is divided into 26 parts to provide for the balanced distribution of up to 13 pairs of wires with both dc and ac isolation. Each output of each printed wiring primary distribution board is provided with a 115-ohm load resistor soldered to the printed wiring path. These resistors terminate unused outputs. The resistors are clipped out and discarded as additional distribution cables are attached. If for some reason one or two of these cables were later disconnected at either end, it would not be necessary to replace the terminating resistors since the isolation between loads is such that an insignificant difference in level

would result. No more than two outlets per board should be left unterminated, however.

Connections to these printed boards are made to solderless wrap terminals mounted on the front edge. The major physical difference between the secondary distribution and the primary distribution panels is that the solderless wrap terminals for interconnection are located on the front of the primary distribution panel and on the back of the secondary distribution panel.

The channel group frequencies and the group carrier frequencies are distributed in a manner similar to the distribution of the channel carriers; however, there is no additional fan out of these frequencies in the secondary distribution panel and the primary distribution requires 26 outputs of each frequency. This additional primary distribution is accomplished by providing two printed cards instead of only one for each of these frequencies. A single filter is used for these frequencies, but its output capacitance is divided 52 times to accommodate the 26 outputs. The filters for all of the frequencies are so designed that each of the isolating output capacitors has the same value.

Fig. 28 indicates the input terminals placed at the bottom of one of the distribution cards and the outputs arranged above them. Distribution to a single office cable requires that the installer connect a separate pair of wires from each cable to a pair of terminals on each of the cards. Each double row of terminals across the primary distribution panel provides the required outputs for a terminal bay containing two N3 terminals. This supplies a total of 16 frequencies, three of which are distributed twice through each cable.

The cards and terminals on them are arranged so as to require a minimum number of connections by both the installer and the factory. The terminals are numbered to provide the same relationship found in a terminal block to which the installer normally connects.

The primary distribution panel is provided with a cover to conceal all of the connections since this area faces the maintenance aisle.

A complete view of the carrier supply showing the primary distribution panel, the protecting switching panel, the 4-kc generator and harmonic filters and the plug-in units and switching and alarm panel is shown in Fig. 20. The relationship of the generating and primary distribution portion of the carrier supply to the secondary distribution and the 13 double bays containing 26 N3 terminals is also shown by this figure.

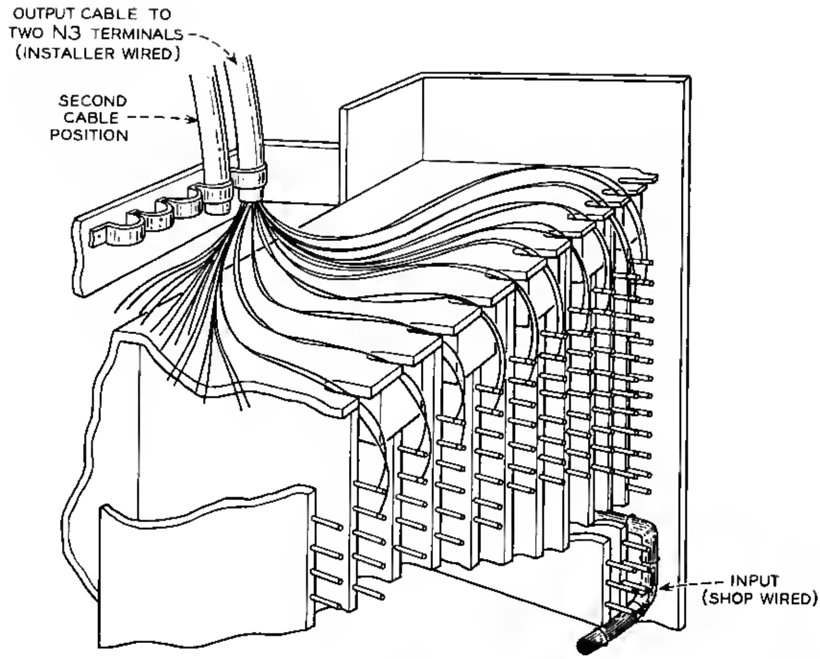


Fig. 28 — Input and output cable connections — primary distribution panel.

XIX. SUMMARY

Equipment design features of the new N3 carrier equipment help substantially in achieving many design objectives. The prime objectives of greatly improved transmission performance, service reliability, and ease of operation and maintenance guided and influenced all equipment design efforts and decisions.

Economy of manufacture results from careful selection of parts and components to assure satisfactory quality at minimum cost. The assembly and wiring of functionally related equipment in a shop-wired package reduces cost, improves noise and crosstalk performance, permits more complete shop testing and simplifies job engineering and installation. Use of the same die cast plug-in unit module frame and the same unit mounting shelf for both terminal and carrier supply achieves economy of manufacturing tooling. Easily removable filters used in certain units reduce the requirements for spare plug-in units.

This new 24-channel terminal provides substantially better performance, requires less space, uses less power, and costs less per installed channel than the equipment it was designed to replace.

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